Dark Contrast

Bright Contrast

B Minus Contrast

SPENCER

Complete EQUIPMENT FOR Phase Microscopy

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10 Maiden Lane
New York, N. Y.

SPENCER

Complete Equipment for PHASE MICROSCOPY

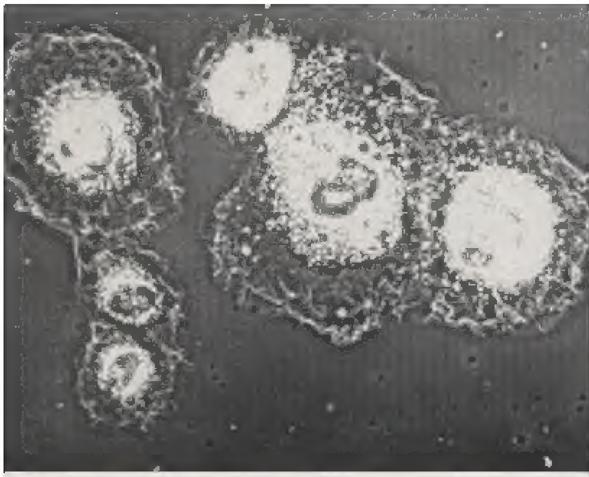
HISTORICAL BACKGROUND

Experiments dating back to the time of Abbe and Bratuscheck had, by 1892, demonstrated that variation or even reversal of contrast can be obtained by introducing suitable absorbing or phase retarding plates in the back focal plane of a microscope objective. In these early experiments, the source of light was limited essentially to a distant point.

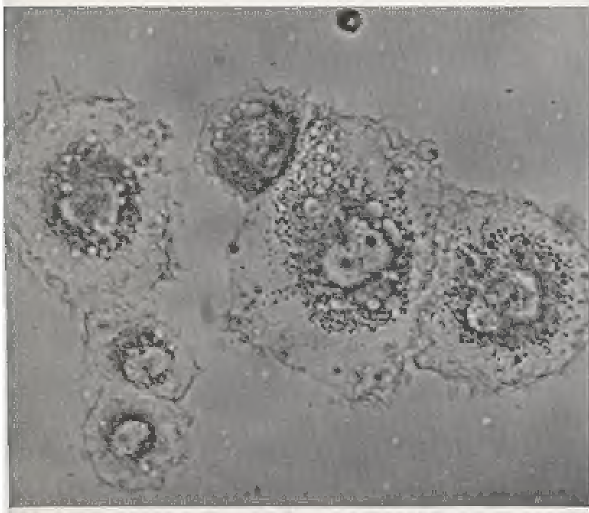
Zernike in 1935 showed that marked changes of contrast can be expected when an object of arbitrary structure is illuminated by a broad light source if a phase plate is placed over the geometrical image of the light source. Patent rights granted to Zeiss indicate that Zernike realized the importance of this method for practical microscopy during or before 1932. Köhler and Loos of Zeiss in 1941 published the results of extensive experiments performed with Zernike's method.

A study of the method was begun at the Scientific Instrument Division of the American Optical Company early in 1941. Results of this work, which included both theoretical and experimental aspects, were reported by Bennett, Richards, Osterberg, and Jupnik (1944). The research staff of this company has expanded the fundamental theory of diffraction phenomena and phase microscopy. This has been accompanied by the practical development of the technique of phase microscopy, which has resulted in a more extensive range of applications. Numerous papers have been written since 1944 on the use of phase microscopy in various fields.

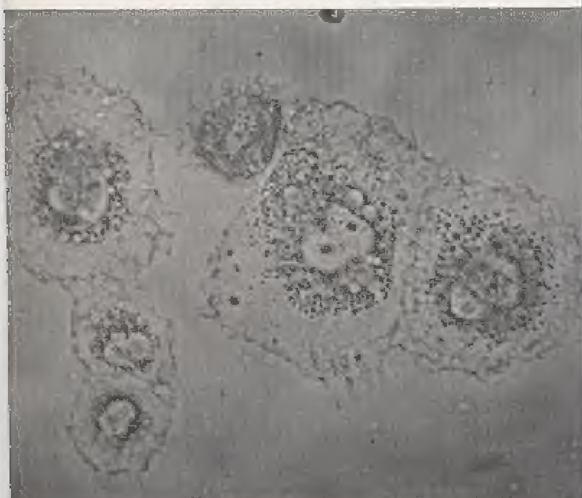
There is a growing interest in the application of phase microscopy to many problems in industrial research, especially in textiles, paper, oil, pharmaceutics, plastics, and glass. Success in using phase usually depends on three considerations: the best type of wave retardation or contrast for the specific purpose, the quality of the optics, and the proper adjustment of the microscope.



Rat Carcinoma (W.R.C. 256), with Bright Contrast-Medium 20X Objective.



Rat Carcinoma (W.R.C. 256), with Dark Contrast-Medium 20X Objective.



Rat Carcinoma (W.R.C. 256), with B Minus Contrast-Low 20X Objective.

All illustrations courtesy Dr. G. O. Gey

Front Cover Illustrations

Top Photo—Young Tissue Culture of Mouse (d br B) Tumor Cells, with Dark Contrast-Medium 10X Objective.

Center photo—Border of Cytoplasmic Spread of *Living* Rat Normal Cell (strain 14p), with Bright Contrast-Medium 97X Objective, showing sharp focus on mitochondria.

Lower photo—Human Sarcoma (strain D), with B Minus Contrast-Low 20X Objective.

Top illustration courtesy Bergman Associates.
Lower 2 illustrations courtesy Dr. G. O. Gey.

THEORY OF PHASE MICROSCOPY

An elementary and non-mathematical explanation of the principles of phase microscopy is necessarily incomplete. The manner in which the laws of diffraction are utilized to enhance contrast in the image will be indicated by the following simplified explanation.

Brief Explanation

Phase Microscopy is essential for the examination of living organisms and tissues, slightly pigmented or faded preparations, emulsions, plastics, and other material too transparent to be seen with bright field microscopy.

In the phase microscope a diffraction plate or coating is added within the objective and an annular diaphragm below the condenser of the bright field microscope, thereby converting slight and invisible alterations of light passing through the specimen into images which may be seen and photographed.

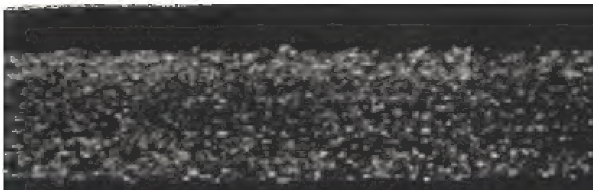
The annulus in the condenser controls the illumination on the diffraction plate or coating, where the light from the specimen and its surround is selectively modified so that it will recombine into an image of adequate visibility. How this is accomplished is explained on this and the following pages, and in the reference cited.

The range of AO Spencer phase objectives makes possible several degrees of contrast, with or without reversing of bright and dark details, to provide best visibility, to emphasize detail, and to insure that no detail is missed in the microscopic examination of such materials.

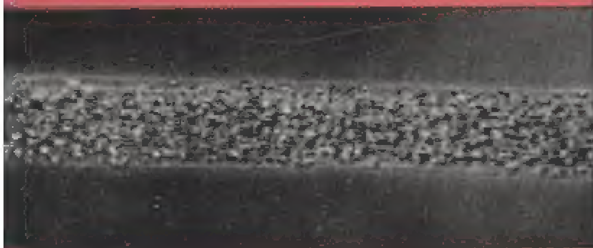
All objectives have incorporated into them the latest developments in this relatively new field. They maintain the high quality always associated with AO Spencer instruments. AO branch offices and distributors stand ready to serve and recommend to prospective users of phase the most suitable equipment. A booklet of instruction is included with each phase microscope and condenser. A bibliography and a chart of 73 applications are available on request.

Phenomena Occurring in All Light Microscopes

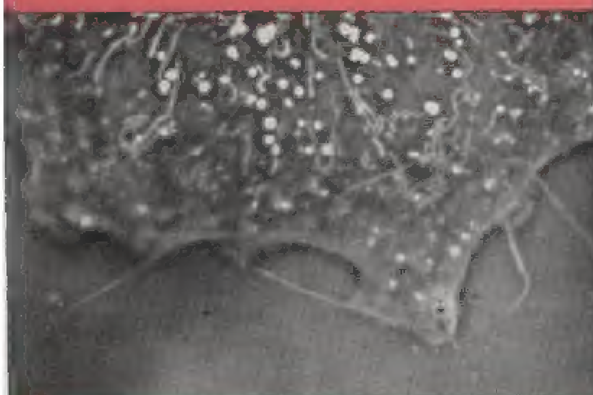
The following will be confined to the common case of a small transparent particle located at the optical axis of a microscope and surrounded by a transparent medium of smaller optical path but of the same light transmission. The optical path is the product of the refractive index and the thickness. Differences in optical path produce phase differences in the transmitted light waves. As illustrated in Fig. 1, the light transmitted through the particle is designated as the wave P, and the light transmitted through the surround as the wave S. The light wave P is retarded by a small amount with respect to the light wave S. It is seen



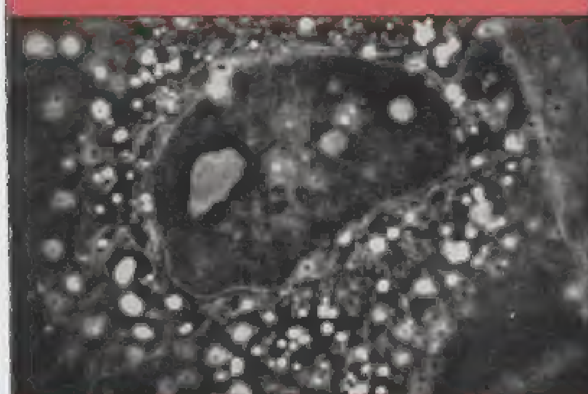
Viscose Rayon dulled with Pigments alone, with Bright Contrast-High 43X Objective.



Viscose Rayon dulled with Pigment and Oil, with Dark Contrast-Medium 45X Objective.



Border of Cytoplasmic Spread of *Living* Rat Normal Cell, with Bright Contrast-Medium 97X Objective, showing filamentous processes, ruffle pseudopodia, and mitochondria.



Border of Cytoplasmic Spread of *Living* Rat Normal Cell, with Bright Contrast-Medium 97X Objective, showing juxta-nuclear components of cell and nuclear details.

Top 2 illustrations courtesy E. C. Jolliff, American Enka Corporation.

Lower 2 illustrations courtesy Dr. G. O. Gey.

from the diagram that the wave P may be considered as the sum of a wave identical with S plus another wave D. This wave D is retarded by approximately ¼ wave length with respect to the wave S so long as the optical path difference between the particle and the surround is small. Thus there exists a wave S transmitted by both the particle and its surround. This wave is called the central wave. The discontinuity in optical path at the edge of the particle produces diffraction, and D is the diffracted wave. The diffraction causes the wave D to be deviated, whereas the central wave is undeviated. The central wave passes through the objective, converges to a focus at the back focal plane of the objective, then spreads over the entire field of the eyepiece. The objective brings the wave D to a focus on that part of the eyepiece field which includes the geometrical image of the particle. At the image of the particle the waves D and S recombine to form the wave P. The image of the surround is formed by the wave S alone. Since the transmissions of the particle and its surround are the same, the waves P and S are of equal amplitude and the image plane shows no contrast.

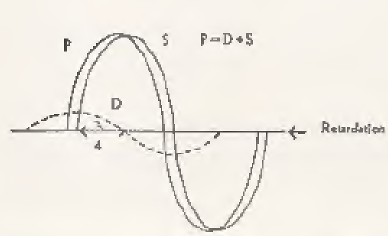


Fig. 1

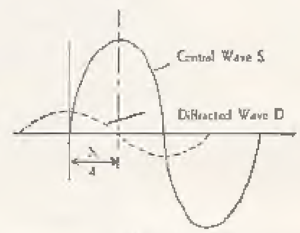


Fig. 2

Phenomena Occurring in the Phase Microscope

Phase microscopy takes advantage of the retardation in phase of the wave D because of diffraction at the specimen.

Fig. 2 shows the relationship between the waves D and S in the region of the eyepiece plane in which they overlap to form the image of the particle. If the central wave is artificially retarded by ¼ wave length, (visualize wave S shifted to the left in Fig. 2) the waves D and S reinforce each other, as in Fig. 3, to form an image of the particle that is brighter than the background. If, on the other hand, the diffracted wave D is artificially retarded by ¼ wave length, (visualize wave D shifted to the left in Fig. 2) the D and S waves will partially cancel each other, as in Fig. 4, to form an image of the particle that is darker than the background.

Most transparent and living materials possess an index higher than the surrounding aqueous medium. In the relatively few cases in which the particle has a slightly smaller optical path than the surround, the S wave is retarded by ¼ wave length with respect to the D wave. It follows that if the central wave is artificially retarded by ¼ wave

length, the particle will appear darker than the background; but if the diffracted wave D is artificially retarded by ¼ wave length, the particle will appear brighter than the background.

The introduction of an artificial retardation thus provides the means for causing a transparent particle to appear brighter than the background (bright contrast) or darker than the background (dark contrast). In the phase microscope this artificial retardation is effected by a diffraction plate.

Additive Superposition of Light Waves.

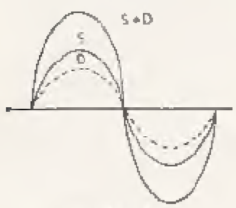


Fig. 3

Subtractive Superposition of Light Waves.

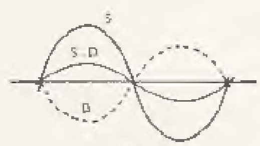


Fig. 4

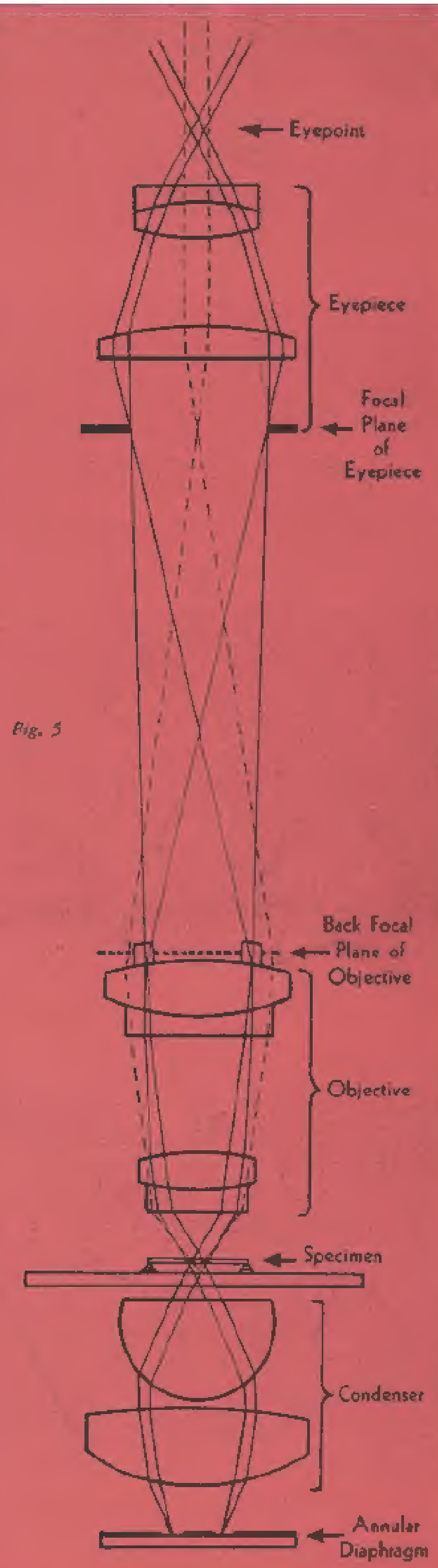
General Optical Arrangement

Fig. 5 is a schematic diagram of the optical arrangement. An annular diaphragm (see Fig. 7) is placed in the lower focal plane of the substage condenser. The bundle shown by solid line in the diagram indicates that light from the opening in the diaphragm, which is not diffracted by the specimen, converges to form the geometrical image of the diaphragm in the back focal plane of the objective. Hence the entire central wave bundle (solid line) is limited to the geometrical image of the condenser diaphragm. On the other hand, the diffracted bundle (dotted line) has been deviated and spread out by the specimen, so that most of this bundle passes through that area of the back focal plane which is not occupied by the geometrical image of the diaphragm. Therefore the image of the diaphragm serves to separate the central wave bundle from the diffracted wave bundle. A diffraction plate (see Fig. 6) is placed at the location of the image.

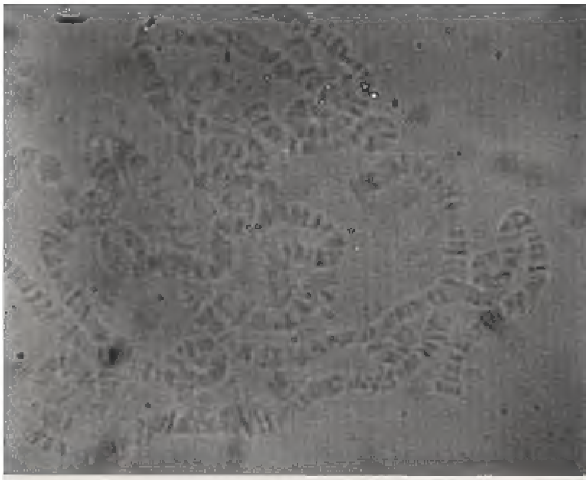
Bright Contrast

Those phase objectives which cause a particle of greater optical path to appear in bright contrast contain a diffraction plate (or coating) consisting of a ring of transparent material of suitable refractive index. This ring is equal in size to the image of the annular diaphragm and is coincident with it. Therefore all the undeviated light (central wave bundle) passes through this annulus ring and is retarded with respect to the deviated (diffracted) light. This retardation is usually ¼ wave length. Finally, the undeviated waves spread out over the entire plane of the eyepiece.

Fig. 5

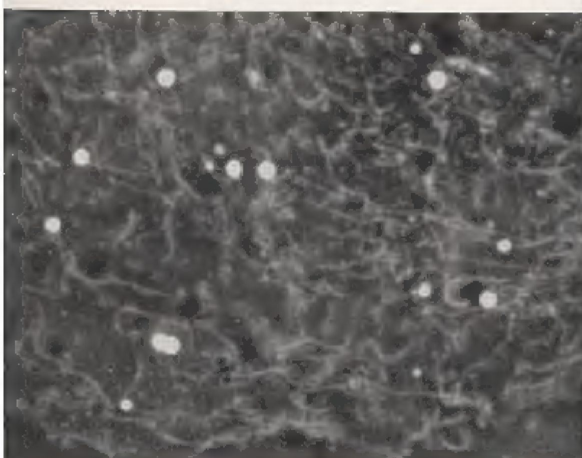


Solid lines represent direct rays.
Dotted lines represent diffracted rays.



Chromosomes of Drosophila, with ordinary Bright Field.

Chromosomes of Drosophila, with Dark Contrast-Medium 97X Objective.



Structural Details of Thin Edge of a *Living* Human Cancer Cell (strain D_1Re), with Bright Contrast-Medium 97X Objective, showing "ruffles", mitochondria, and a few fat droplets.

Lower illustration courtesy Dr. G. O. Gey.

The diffracted light enters the objective, passes through the diffraction plate, and is brought to a focus at the focal plane of the eyepiece. In the ideal case of bright contrast, the retardation introduced by the diffraction plate causes the central and diffracted waves to arrive at the image plane in phase. Therefore, at the plane of the eyepiece at which the diffracted rays are brought to a focus, the amplitude of the diffracted waves is reinforced by the addition of the central wave as in Fig. 3. This results in increased brightness at these points of the image plane. Therefore, a difference in refractive index and/or thickness has been transformed into a difference in brightness.

In most cases, particularly when the differences in optical path in the specimen are small, the amplitude of the central wave bundle forming the background illumination is much greater than the amplitude of the diffracted light bundle (see Fig. 2). Consequently, the gain in brightness described above would not be very noticeable. To increase the contrast it is necessary to weaken the central wave; i.e., the direct background illumination. This is accomplished by coating the phase-retarding ring of the diffraction plate with a light absorbing layer.

Varying degrees of contrast can be obtained with different values of light transmission in these light-absorbing coatings.

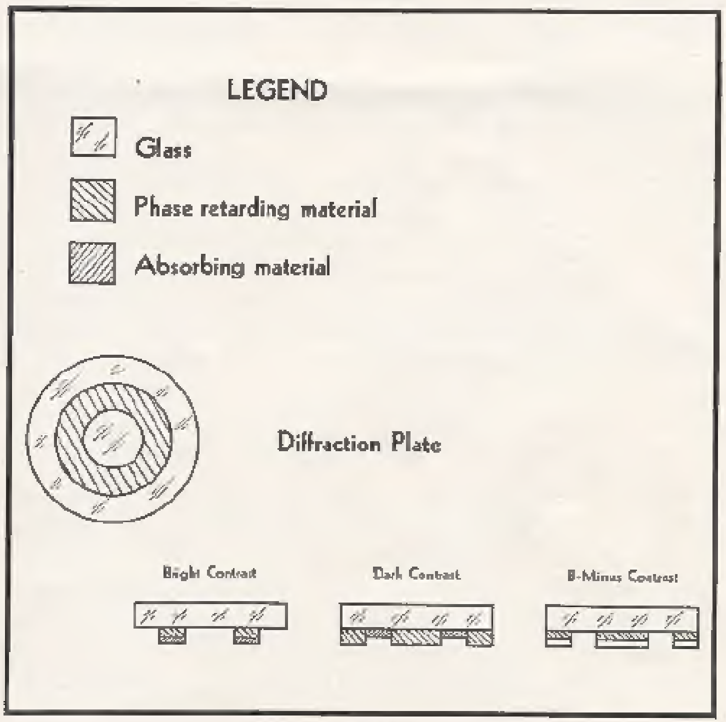


Fig. 6

Dark Contrast

In many instances it is desirable to make particles of higher refractive index and/or greater thickness appear darker than the background.

Dark contrast phase objectives contain diffraction plates in which the area through which the central wave passes is free from phase-retarding material. Instead, diffracted light is further retarded by the presence of phase-retarding material in the area adjacent to the ring-shaped area. In the ideal case, the diffracted wave will be so retarded by the diffraction plate that it will arrive at the image plane ½ wave length out of phase with the central wave. In that case, the diffracted and central waves will partially cancel each other as in Fig. 4. Also, as in bright contrast phase objectives, it is usually necessary to weaken the central wave bundle by depositing absorbing material on the ring-shaped area of the diffraction plate.

B Minus Contrast

This type of objective produces a dark contrast without diminishing the central wave; i.e., background illumination. It is particularly useful for material containing light-absorbing components in addition to phase-changing particles. Lightly stained or pigmented material and material containing light-absorbing cell boundaries belong to this group.

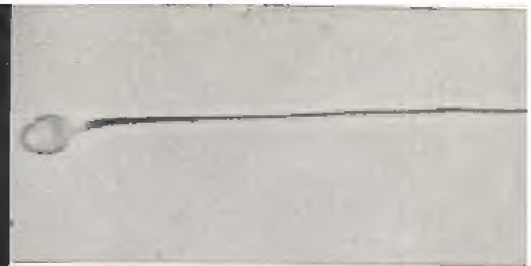
The diffraction coatings contained in objectives of the B Minus series contain phase-retarding material with or without light-absorbing coatings placed outside the ring-shaped area, which is left clear.

The American Optical Company offers a useful selection of phase microscope objectives in four magnifications. Most of these are available in three types of contrast and in three gradations. Objectives required for special purposes with different gradations from those listed can usually be supplied on special order.

1.8mm 4mm 8mm 16mm

Annular Diaphragms

Fig. 7



Human Spermatozoon, with Dark Contrast-Medium 43X Objective.

Human Spermatozoon, with Dark Contrast-Medium 43X Objective.

Lanaset Resin Treated Wool Fiber, with Bright Contrast-High 97X Objective, showing deposit essentially at scale interstices.

Lanaset Treated Wool Fiber after Removal of Cortex with Sodium Sulfide Solution, leaving sausage casing effect of resin-bonded or strengthened scale structure, with Bright Contrast-High 97X Objective.

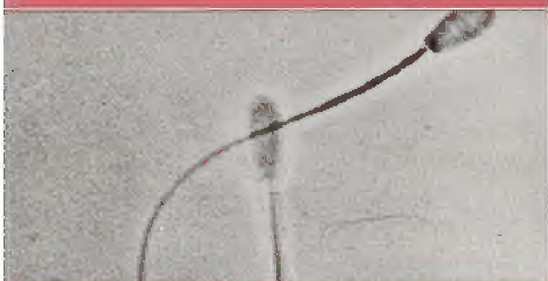
Top 2 illustrations from Human Fertility and Problems of the Male, *by E. J. Farris, Ph.D., 1950. Reproduced by permission of The Author's Press, Inc., White Plains, New York.*

Lower 2 illustrations courtesy Calco Chemical Division, American Cyanamid Company.

SPENCER

Since the introduction of the No. 18 AO Spencer Phase Microscope, a very large number of complete microscopes and accessory phase outfits have been purchased for research in the fields of biological and physical science. These microscopes and accessories are in daily use at most of the important research institutions and outstanding hospitals in the United States, Canada, and throughout the world.

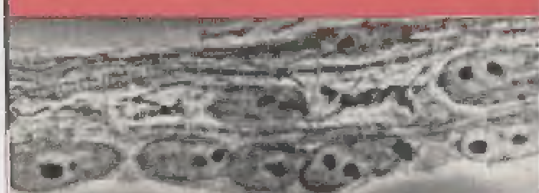
Spermatozoa of Yorkshire Pig, with Dark Contrast-Medium 43X Objective.



Spermatozoa of Guernsey Bull, with Dark Contrast-Medium 43X Objective.

Spermatozoon of Horse, Standard Breed, with Dark Contrast-Medium 43X Objective.

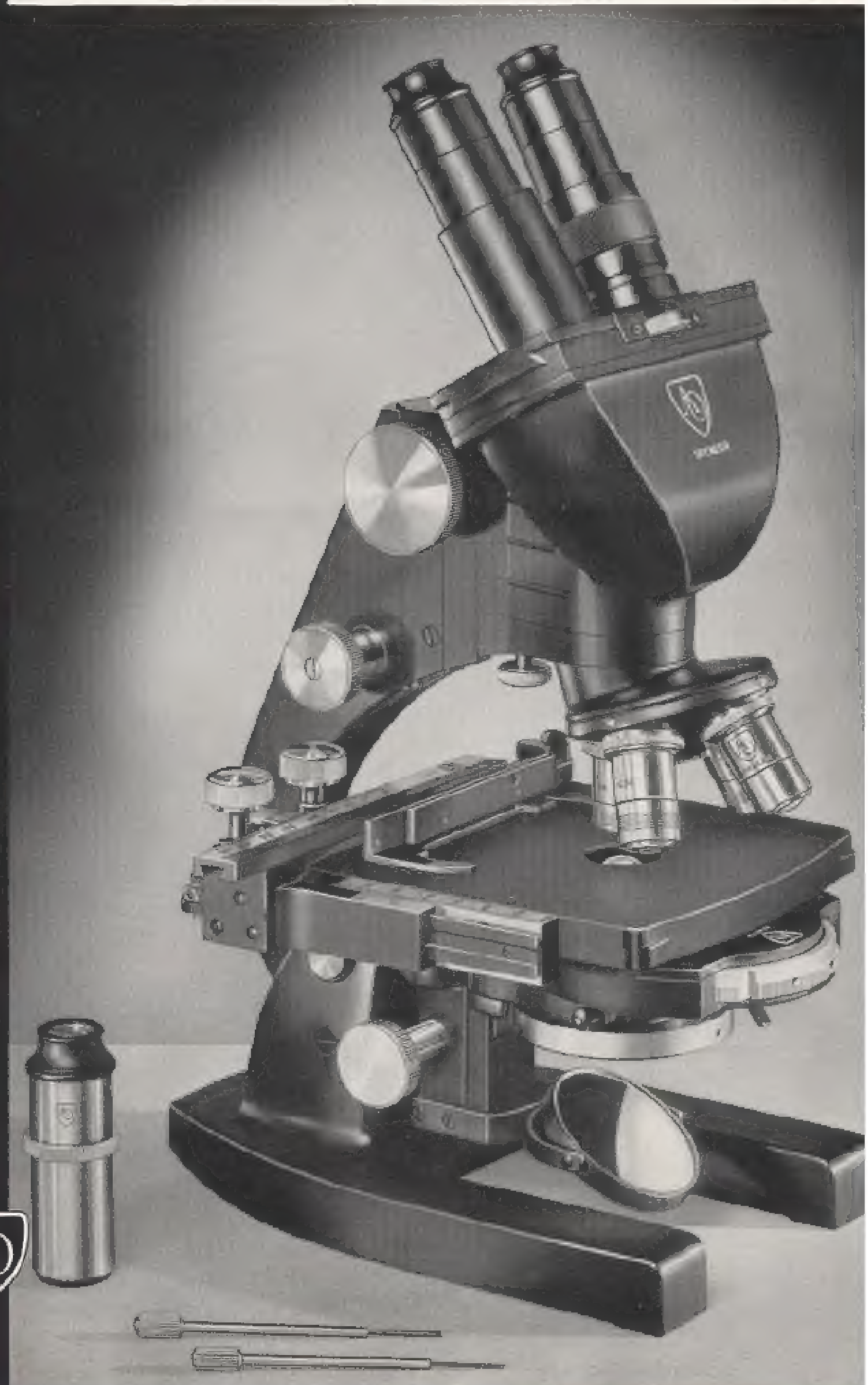
Spermatozoon of Hamster, with Bright Contrast-Medium 43X Objective.



Muscle Fibers from Developing Leg of Chicken teased out with needles, with Dark Contrast-Medium 97X Objective.

Top 4 illustrations from Human Fertility and Problems of the Male, *by E. J. Farris, Ph.D., 1950. Reproduced by permission of The Author's Press, Inc., White Plains, New York.*

Lower illustration courtesy P. H. Ralph, University of Washington

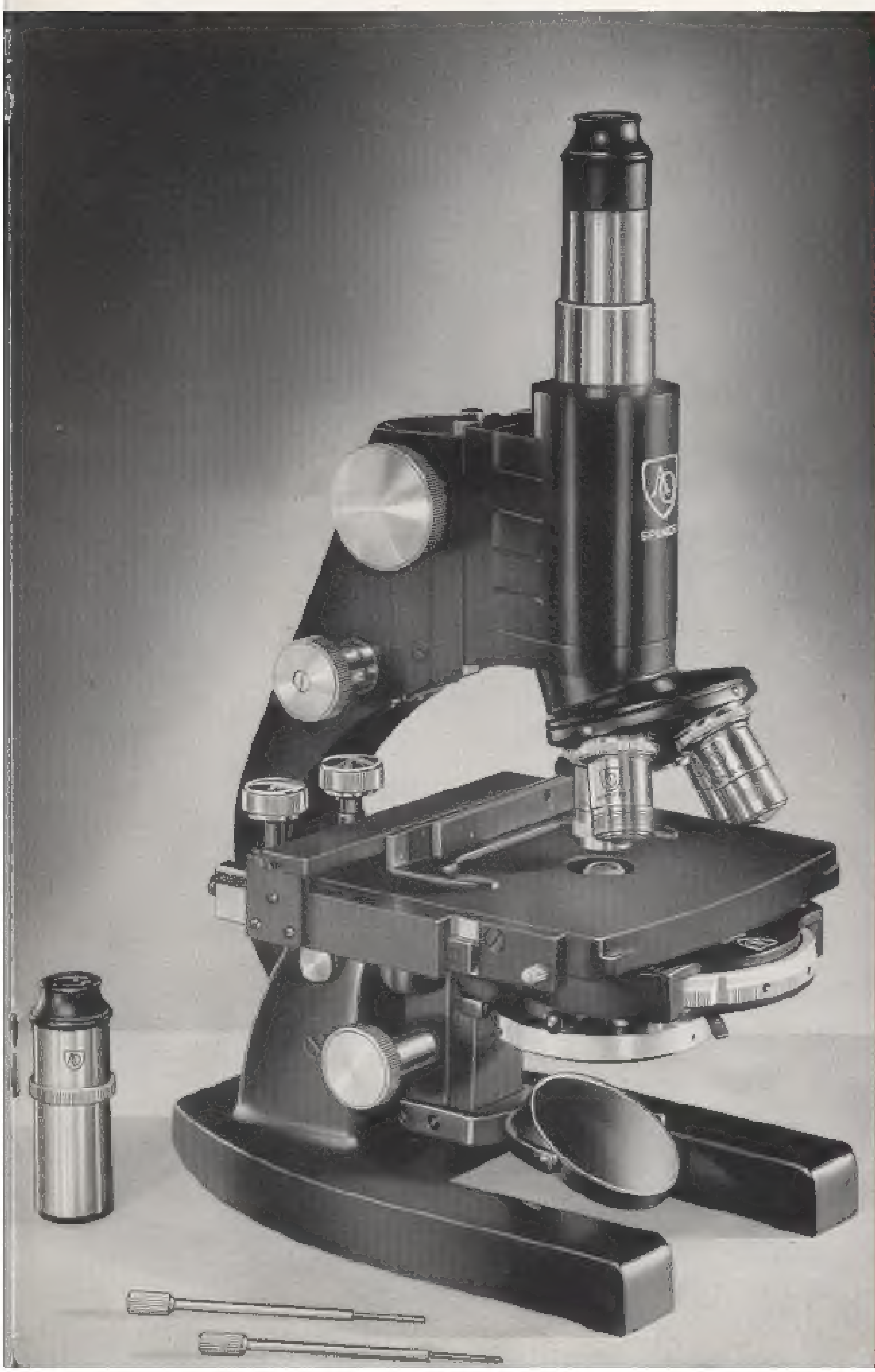


HASE MICROSCOPE

Phase has also found its place in many industrial laboratories.

A new AO Spencer Phase Microscope stand is now available. Based on the recently announced No. 15 and No. 35 Microscope stands, it incorporates many new optical and mechanical improvements for the comfort and convenience of the user. Most of the features are common to both the binocular and monocular models.

Complete Listing on Following Page



FEATURES OF ALL AO SPENCER PHASE MICROSCOPES

STAND: Strong, rigid, lightweight, aluminum arm and base, with exceptionally sturdy and long wearing inclination joint.

COARSE ADJUSTMENT: Rack-and-pinion. Tension adjustable to the individual touch.

FINE ADJUSTMENT: Accurate throughout range of travel. Ball-bearing, micrometer-screw type, graduated in 2-micron divisions. Spring loading eliminates backlash.

NOSEPIECE: Quadruple revolving, dual-cone, with improved ball-and-groove spring stop to assure correct alignment of objectives.

SUBSTAGE: Rack-and-pinion type, with adjustable tension dual control knobs. Fork-type mount for easy removal of the phase condenser.

CONDENSER: Turret N.A. 1.25 Abbe, with 1 clear aperture and 4 annular diaphragms to suit powers of objectives selected. (See detailed description page 11).

CENTERING TELESCOPE: Supplied with condenser in separate leatherette covered case. Case can accommodate 8 objectives.

MIRROR: Double plano, in fork mount.

CABINET: Gray leatherette covered hardwood, with space for accessory case.

SPECIAL FEATURES OF BINOCULAR MODELS

BODY: Inclined binocular body, removable to allow attachment of monocular body for photomicrography.

STAGE: Bakelite, 125 mm square with built-on M (ungraduated) or Q (graduated) mechanical stage. "Pinch grip" action facilitates placement of slides.

EYEPIECES: Paired 10X Phase High Eyepoint.

SPECIAL FEATURES OF MONOCULAR MODELS

BODY: Non-interchangeable monocular body, with 160 mm tube length.

STAGE: Bakelite, 125 mm square with built-on M (ungraduated) mechanical stage. "Pinch grip" action facilitates placement of slides.

EYEPIECES: 10X Phase High Eyepoint.

Complete Listing of Phase Microscopes

Cat. No.	Body	Stage	OPTICAL OUTFITS Centering Telescope included with all outfits		
			Objectives on Quadruple Nosepiece	Eyepieces	Condenser
8MLS	Inclined Binocular	M	None	Paired 10X Phase High Eyepoint	Turret N.A. 1.25 with 4 annular diaphragms and 1 clear aperture
8QLS	Inclined Binocular	Q	None	Paired 10X Phase High Eyepoint	Turret N.A. 1.25 with 4 annular diaphragms and 1 clear aperture
8MLSP	Inclined Binocular	M	10X, 20X, 43X, 97X Dark Contrast-Medium	Paired 10X Phase High Eyepoint	Turret N.A. 1.25 with 4 annular diaphragms and 1 clear aperture
8QLSP	Inclined Binocular	Q	10X, 20X, 43X, 97X Dark Contrast-Medium	Paired 10X Phase High Eyepoint	Turret N.A. 1.25 with 4 annular diaphragms and 1 clear aperture
8MLSN	Inclined Binocular	M	10X, 20X, 43X, 97X Dark Contrast-Medium 10X, 20X, 43X, 97X Bright Contrast-Medium	Paired 10X Phase High Eyepoint	Turret N.A. 1.25 with 4 annular diaphragms and 1 clear aperture
8QLSN	Inclined Binocular	Q	10X, 20X, 43X, 97X Dark Contrast-Medium 10X, 20X, 43X, 97X Bright Contrast-Medium	Paired 10X Phase High Eyepoint	Turret N.A. 1.25 with 4 annular diaphragms and 1 clear aperture
8MLSO	Inclined Binocular	M	10X, 20X, 43X, 97X Dark Contrast-Medium 10X, 20X, 43X, 97X Bright Contrast-Medium 10X, 20X, 43X, 97X B Minus Contrast-Low	Paired 10X Phase High Eyepoint	Turret N.A. 1.25 with 4 annular diaphragms and 1 clear aperture
8QLSO	Inclined Binocular	Q	10X, 20X, 43X, 97X Dark Contrast-Medium 10X, 20X, 43X, 97X Bright Contrast-Medium 10X, 20X, 43X, 97X B Minus Contrast-Low	Paired 10X Phase High Eyepoint	Turret N.A. 1.25 with 4 annular diaphragms and 1 clear aperture
8MS	Monocular	M	None	Paired 10X Phase High Eyepoint	Turret N.A. 1.25 with 4 annular diaphragms and 1 clear aperture
8QS	Monocular	Q	None	Paired 10X Phase High Eyepoint	Turret N.A. 1.25 with 4 annular diaphragms and 1 clear aperture
8MSP	Monocular	M	10X, 20X, 43X, 97X Dark Contrast-Medium	Paired 10X Phase High Eyepoint	Turret N.A. 1.25 with 4 annular diaphragms and 1 clear aperture
8QSP	Monocular	Q	10X, 20X, 43X, 97X Dark Contrast-Medium	Paired 10X Phase High Eyepoint	Turret N.A. 1.25 with 4 annular diaphragms and 1 clear aperture

AO SPENCER PHASE ACCESSORIES

TURRET CONDENSERS

AO Spencer Phase Turret Condensers are made in two types. The condensers supplied with Cat. Nos. 1000165, 1000166, and 1000250 are designed to fit the heavier fork-type substage now supplied on AO Spencer Microscopes Nos. 15, 17, 19, 35, 72, and 76. They are supplied in a hardened steel, centerable mount which fits into the fork-type substage with a 3-point contact. A knurled lock screw is provided at the left side of the substage fork to hold the condenser rigidly in place. In this manner a tilt or rotation of the condenser optics is prevented and correct alignment of the annular diaphragm assured.

The phase turret condensers supplied with Cat. Nos. 1000160, 1000161, and 1000150 are designed to fit the fork type substages of the AO Spencer Microscopes Nos. 10, 11, 13, 14, 33, 60, 61, and 62. Upon special order adapters can be made to fit this condenser to ring type substages of other makes of microscopes provided that the stage thickness does not exceed ⅜″ (or 9.5 mm). When ordering give make and model number of your microscope.

AO Phase Turret Condensers contain a rotatable turret with four individually centerable cells (stainless steel) with interchangeable annular diaphragms and one clear aperture. An iris diaphragm is located below the turret. The clear aperture in the turret permits comparisons between phase and ordinary bright field microscopy. The annular diaphragms normally supplied with the turret condenser correspond to objective magnifications 10X, 20X, 43X, 97X.

The four annular diaphragms are individually adjustable to any series of four objectives contained in the quadruple nosepiece of the microscope.

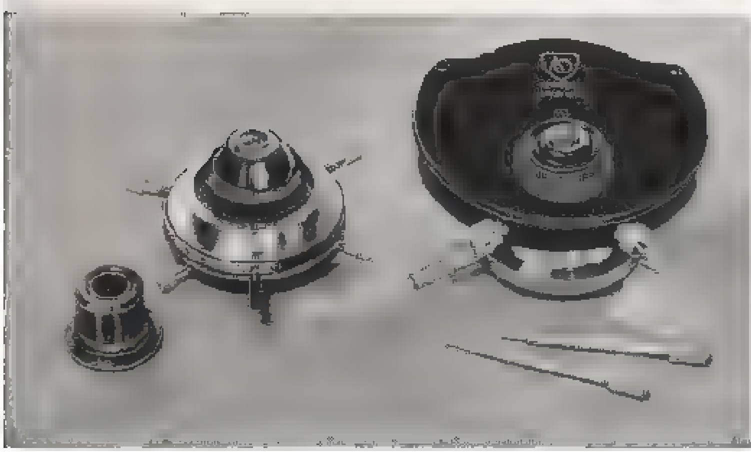
The individual centering of the annular diaphragms is easily accomplished by using the centering telescope and a pair of centering wrenches supplied with the condenser.

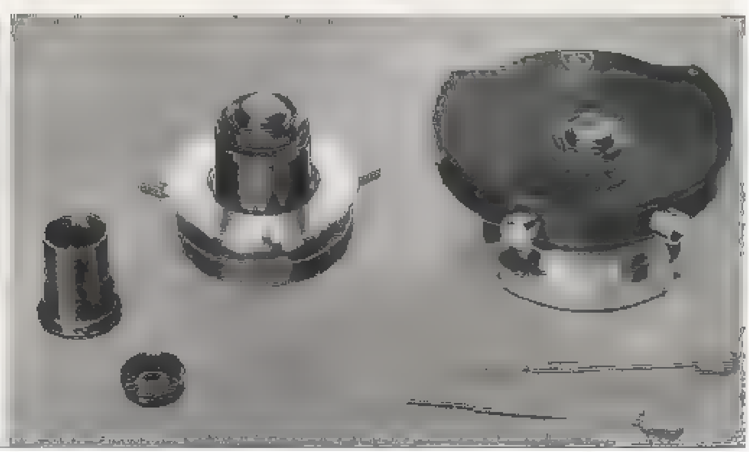
The Abbe-type condenser N.A. 1.25 has two lens elements. The lower lens element alone can be used for long focus work up to 15 mm above the stage of the No. 8, 15, 35 Spencer Microscopes and up to 17 mm above the No. 18, 13, 33, and similar microscopes with stages of ⅜″ (or 9.5 mm) thickness.

If the lower lens element is combined with an N.A. 0.66 top element, the working distance (in air) above the stage is 6 to 7 mm. For long focus work it will be necessary to insert 10X, 20X, 43X long focus annular diaphragms into the centerable cells of the turret.

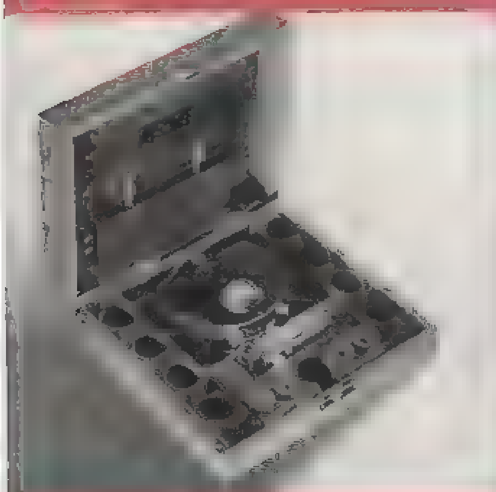
AO Spencer Phase Turret Condensers

Cat. No.	Annular Diaphragms 10X, 20X, 43X, 97X	Phase Objectives 10X, 20X, 43X, 97X	Telescope	For use on Microscopes
1000250	One of each	None	Centering	15, 17, 19, 35, 72, 76
1000165	One of each	Dark Contrast-Medium	Centering	15, 17, 19, 35, 72, 76
1000166	One of each	Bright Contrast-Medium Dark Contrast-Medium	Centering	15, 17, 19, 35, 72, 76
1000150	One of each	None	Centering	10, 11, 13, 14, 33, 60, 61, 62
1000160	One of each	Dark Contrast-Medium	Centering	10, 11, 13, 14, 33, 60, 61, 62
1000161	One of each	Bright Contrast-Medium Dark Contrast-Medium	Centering	10, 11, 13, 14, 33, 60, 61, 62





No. 8MLS Microscope tilted to show phase turret condenser



No. [illegible] Phase Turret Condenser

No. [illegible] Phase Single Unit Condenser

SINGLE UNIT CONDENSERS

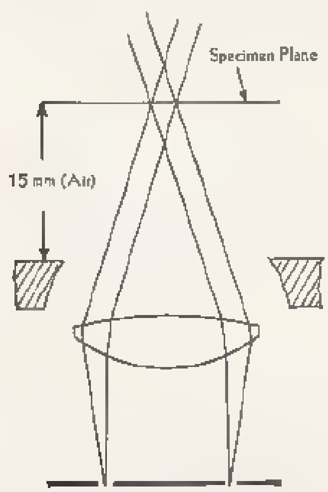
AO Spencer Single Unit Condensers are recommended where microscopic examinations are made mainly at one magnification and where a rapid change from phase microscopy to ordinary bright field microscopy is not essential

Two models of condenser outfits are available No. 1000125 is for Spencer Microscopes Nos. 10, 11 13, 14, 18, 33, 60, 61, and 62. This model cannot be used for long focus work, nor can it be adapted to stands with thick stages. It contains an iris diaphragm for bright field microscopy and has centering screws for the condenser as well as for the annular diaphragms.

No. 1000135 is for Spencer Microscopes Nos. 15, 17, 19, 35, 72, and 76 If the fork-type sleeve is removed, it may be used for ring type substages of 37 mm diameter With the aid of special adapter rings, it may be adapted to substages of 39 mm and other diameters. This phase condenser will fit the majority of thick stages. For use on unusually thick stages (e.g. Spencer X Stage) special paired adapters can be made to increase the height of the condenser and of the holder for the annular diaphragm.

The No. 1000135 Single Unit Phase Condenser utilizes the same optics and annular diaphragms, including long focus accessories, as the Spencer Phase Turret Condenser. For the sake of adaptability to a great variety of makes of microscopes and types of stages, the iris diaphragm and the centering motion for the condenser have been omitted in this model.

1000135	Single Unit Phase Condenser with centering telescope but without annular diaphragms or objectives, in case
1000125	Single Unit Phase Condenser with centering telescope, but without annular diaphragms or objectives, in case

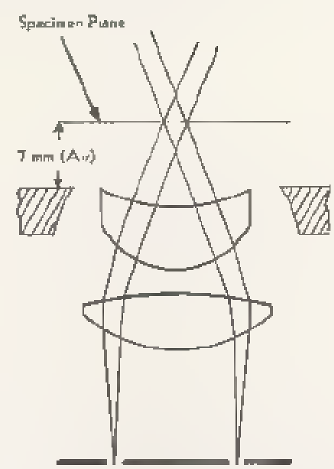


LONG FOCUS

OBJECTIVES: 10X, 20X

APPLICATION: Micromanipulation
Tissue Cultures

Fig 8



LONG FOCUS

OBJECTIVES: 43X

APPLICATION: Thick Slides
Haemacytometers

Fig 9

ANNULAR DIAPHRAGMS

AO Spencer Annular Diaphragms are available in two sizes. When ordering additional ones, be sure to specify the correct type for your condenser

For All Turret Condensers and Single Unit Phase Condenser No. 1000135:		For Single Unit Phase Condenser No. 1000125	
1000109	10X Annular Diaphragm	1000001	10X Annular Diaphragm
1000102	20X Annular Diaphragm	1000002	20X Annular Diaphragm
1000103	43X Annular Diaphragm	1000003	43X Annular Diaphragm
1000104	97X Annular Diaphragm	1000004	97X Annular Diaphragm

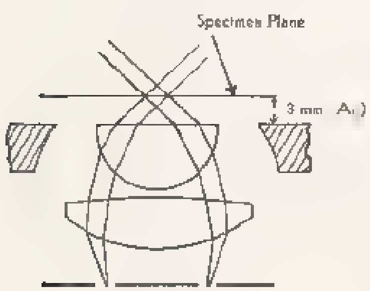
LONG FOCUS EQUIPMENT

AO Spencer Long Focus Equipment has been designed to provide the microscopist with an adequate working distance between condenser and specimen. It is especially valuable for micromanipulation, hanging drop cultures, study of blood circulation in animals, examination of glass and plastic. It is important to select slides of uniform thickness and free from striations. Slides which lack parallelism prevent the correct alignment of the annular diaphragm image with the diffraction rings in the objective. Hollow ground slides may occasionally be used for hanging drop preparations, although flat bottomed slides are preferable

Problems arising from slides or glass cells of unusual dimensions can frequently be overcome by modifying the equipment described above.

For All Turret Condensers and Single Unit Phase Condenser No. 1000135:

1000110	10X Long Focus Annular Diaphragm	*Use with lower lens element, e.g. Fig 8*
1000106	20X Long Focus Annular Diaphragm	
1000107	43X Long Focus Annular Diaphragm	*Use these together, e.g. Fig 9*
1000306	Top Element, N.A. 0.66 Condenser	
1000303	Reduced Thickness Top Element N.A. 1.25 Condenser, use with 1000109, 1000102, 1000103, 1000104; e.g. Fig. 10	

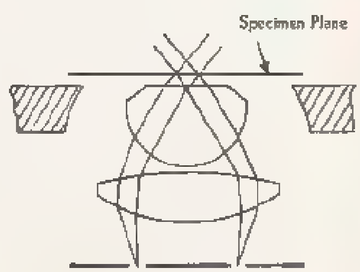


LONG FOCUS

OBJECTIVES: 97X, 43X, 20X, 10X

APPLICATION: Thick Slides

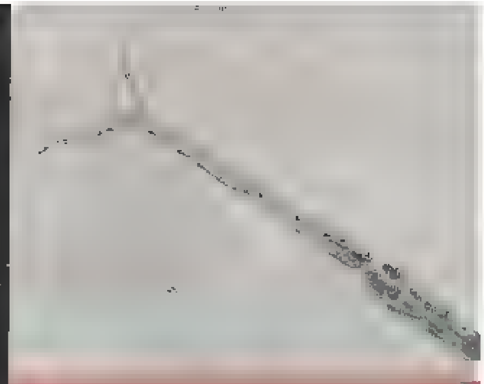
Fig 10

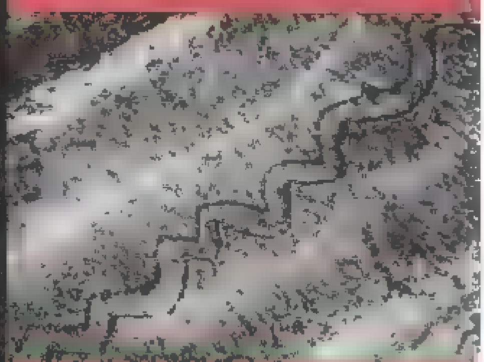


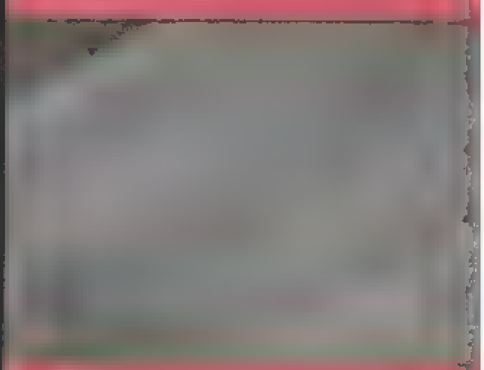
STANDARD

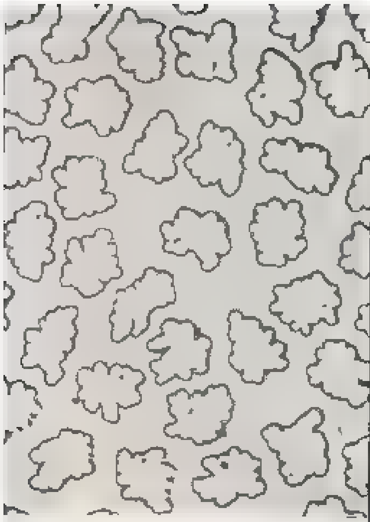
OBJECTIVES: 97X, 43X, 20X, 10X

Fig 11









Bright Viscose Rayon, with ordinary Bright Field.

Viscose Rayon dulled with Pigment alone, with Dark Contrast-Medium 43X Objective

Viscose Rayon dulled with Pigment alone, with Bright Contrast High 43X Objective.

All illustrations courtesy F. C. Joliff American Enka Corporation.

PHASE OBJECTIVES

AO Spencer Phase Objectives are achromatically corrected. They are available in three types of contrast: Bright, Dark, and B Minus. Many objectives are available in three degrees of contrast: low, medium, and high.

The most generally useful objectives are Bright Contrast-Medium, Dark Contrast-Medium, and B Minus Contrast-Low. They are supplied on those instruments which are listed as completely equipped microscopes.

The choice of contrast depends on the nature of the specimen. Generally speaking, Dark Contrast represents an appearance similar to stained specimens, with the material of greater thickness or higher refractive index darker than the background. Bright Contrast is the reverse. It is particularly useful for making very fine detail and small particles more conspicuous than they would be in Dark Contrast. B Minus Contrast produces a very low dark contrast. It is recommended for supravitally stained material, old faded (previously stained) slides and pigmented material. Light-absorbing cell walls appear much clearer. Small fat droplets in tissue cultures or in emulsions appear much clearer than in the bright or dark contrast. The B Minus objective is particularly useful for photomicrography in natural colors as it does not produce any excessive brightening or darkening of the color values.

Cover glass Correction:

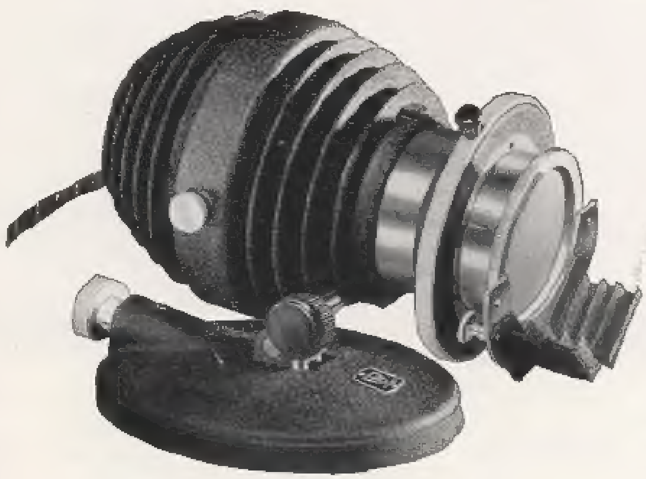
Slight deviations from the correct cover-glass thickness (0.18 mm) can usually be tolerated except in the case of the 43X (4mm) high dry objectives. In this case the cover glass thickness should be held within the limits of 0.16 mm and 0.20 mm.

2120109W	10X Phase Objective, Bright Contrast Medium
2220109W	10X Phase Objective, Dark Contrast Medium
8420109W	10X Phase Objective, B Minus Contrast-Low
3120109W	10X Phase Objective, Bright Contrast Low
3220109W	10X Phase Objective, Dark Contrast Low
2120112W	20X Phase Objective, Bright Contrast-Medium
2220112W	20X Phase Objective, Dark Contrast-Medium
8420112W	20X Phase Objective, B Minus Contrast Low
3120112W	20X Phase Objective, Bright Contrast Low
3220112W	20X Phase Objective, Dark Contrast-Low
2120115W	43X Phase Objective, Bright Contrast Medium
2220115W	43X Phase Objective, Dark Contrast Medium
8420115W	43X Phase Objective, B Minus Contrast-Low
3120115W	43X Phase Objective, Bright Contrast-Low
1120115W	43X Phase Objective, Bright Contrast-High
3220115W	43X Phase Objective, Dark Contrast-Low
6420115W	43X Phase Objective, B Minus Contrast-Medium
2120127W	97X Phase Objective, Bright Contrast-Medium
2220127W	97X Phase Objective, Dark Contrast-Medium
8420127W	97X Phase Objective, B Minus Contrast-Low
3120127W	97X Phase Objective, Bright Contrast-Low
1120127W	97X Phase Objective, Bright Contrast-High
3220127W	97X Phase Objective, Dark Contrast-Low
6420127W	97X Phase Objective, B Minus Contrast-Medium

EYEPIECES

Three types of eyepieces are offered for use on Phase Microscopes: Huygenian, Wide Field, and Phase High Eyepoint. The latter have the same sized field as the Huygenian, but have higher eyepoints, and are therefore recommended for those who wear glasses.

1142	Paired 10X Huygenian Eyepieces	1182	Paired 15X Phase High Eyepoint Eyepieces
142	Single 10X Huygenian Eyepiece	182	Single 15X Phase High Eyepoint Eyepiece
1181	Paired 10X Phase High Eyepoint Eyepieces	1135	Paired 10X Wide Field Eyepieces
181	Single 10X Phase High Eyepoint Eyepiece	135	Single 10X Wide Field Eyepiece



MICROSCOPE ILLUMINATOR

AO Spencer Microscope Lamp No. 735C is recommended for phase microscopy on account of its efficient design and convenient adjustments. An iris diaphragm, blue and ground glasses, multiple filter holder, 100-watt bulb, and an 8-foot cord with switch are included.

CENTERING TELESCOPE

AO Spencer Centering Telescope No. 1000900 may be ordered separately. It is supplied with all Phase Microscopes and Condenser Kits.

NEUTRAL DENSITY FILTER

Neutral Density Filter No. 743 with 50% transmission will be found most helpful with B Minus Contrast-Low Objectives, as it diminishes excessive brightness without changing the natural color of the specimen.

SINGLE BODY TUBE

Single Body Tube with adjustable drawtube, No. 85 is recommended for photomicrography. It can be attached in place of the binocular body.

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Price List

AO SPENCER PHASE MICROSCOPE

Catalog M152-950

Cat. No.	Description	Price
8MLS	Phase Microscope, binocular, without objectives	$ 595.00
8QLS	Phase Microscope, binocular, without objectives	610.00
8MLSP	Phase Microscope, binocular, with 4 objectives (Dark-Medium)	965.00
8QLSP	Phase Microscope, binocular, with 4 objectives (Dark-Medium)	980.00
8MLSN	Phase Microscope, binocular, with 8 objectives (Dark-Medium, Bright-Medium)	1335.00
8QLSN	Phase Microscope, binocular, with 8 objectives (Dark-Medium, Bright-Medium)	1350.00
8MLSO	Phase Microscope, binocular, with 12 objectives (Dark-Medium, Bright-Medium, B Minus-Low)	1705.00
8QLSO	Phase Microscope, binocular, with 12 objectives (Dark-Medium, Bright-Medium, B Minus-Low)	1720.00
8MS	Phase Microscope, monocular, without objectives	396.00
8QS	Phase Microscope, monocular, without objectives	411.00
8MSP	Phase Microscope, monocular, with 4 objectives (Dark-Medium)	766.00
8QSP	Phase Microscope, monocular, with 4 objectives (Dark-Medium)	781.00
1000250	Phase Turret Condenser for Nos. 15, 17, 19, 35, 72, 76 Microscopes, without objectives with Centering Telescope in case	195.00
1000165	Phase Turret Condenser for Microscopes Nos. 15, 17, 19, 35, 72, 76, with 4 Phase objectives (Dark-Medium) with Centering Telescope in case	565.00
1000166	Phase Turret Condenser with 8 Phase objectives (Dark-Medium, Bright-Medium) for Microscopes Nos. 15, 17, 19, 35, 72, 76 with Centering Telescope in case	935.00
1000150	Phase Turret Condenser without objectives, for Microscopes Nos. 10, 11, 13, 14, 33, 60, 61, 62 with Centering Telescope in case	195.00
1000160	Phase Turret Condenser with 4 Phase objectives (Dark-Medium) for Microscopes Nos. 10, 11, 13, 14, 33, 60, 61, 62 with Centering Telescope in case	565.00
1000161	Phase Turret Condenser with 8 Phase objectives (Dark-Medium, Bright-Medium) for Microscopes Nos. 10, 11, 13, 14, 33, 60, 61, 62 with Centering Telescope in case	935.00
1000135	Single Unit Condenser without objectives, for Microscopes Nos. 15, 17, 19, 35, 72, 76 with Centering Telescope in case	90.00
1000125	Single Unit Condenser without objectives, for Microscopes Nos. 10, 11, 13, 14, 33, 60, 61, 62 with Centering Telescope in case	90.00
1000109	10X Annular Diaphragm for No. 1000135 and Turret Condensers	12.00
1000102	20X Annular Diaphragm for No. 1000135 and Turret Condensers	12.00
1000103	43X Annular Diaphragm for No. 1000135 and Turret Condensers	12.00
1000104	97X Annular Diaphragm for No. 1000135 and Turret Condensers	12.00
1000001	10X Annular Diaphragm for No. 1000125 Condenser	18.00
1000002	20X Annular Diaphragm for No. 1000125 Condenser	18.00
1000003	43X Annular Diaphragm for No. 1000125 Condenser	18.00
1000004	97X Annular Diaphragm for No. 1000125 Condenser	18.00
1000110	10X Long Focus Annular Diaphragm for No. 1000135 and Turret Condensers	18.00
1000106	20X Long Focus Annular Diaphragm for No. 1000135 and Turret Condensers	18.00

Cat. No.	Description	Price
1000107	43X Long Focus Annular Diaphragm for No. 1000135 and Turret Condensers ...... $	18.00
1000306	Top Element, N. A. 0.66 Condenser for No. 1000135 and Turret Condensers	15.00
1000303	Reduced Thickness Top Element, N. A. 1.25 for No. 1000135 and Turret Condensers	20.00
2120109W	10X Phase Objective, Bright Contrast-Medium	70.00
2220109W	10X Phase Objective, Dark Contrast-Medium	70.00
8420109W	10X Phase Objective, B Minus Contrast-Low	70.00
3120109W	10X Phase Objective, Bright Contrast-Low	70.00
3220109W	10X Phase Objective, Dark Contrast-Low	70.00
2120112W	20X Phase Objective, Bright Contrast-Medium	85.00
2220112W	20X Phase Objective, Dark Contrast-Medium	85.00
8420112W	20X Phase Objective, B Minus Contrast-Low	85.00
3120112W	20X Phase Objective, Bright Contrast-Low	85.00
3220112W	20X Phase Objective, Dark Contrast-Low	85.00
2120115W	43X Phase Objective, Bright Contrast-Medium	95.00
2220115W	43X Phase Objective, Dark Contrast-Medium	95.00
8420115W	43X Phase Objective, B Minus Contrast-Low	95.00
3120115W	43X Phase Objective, Bright Contrast-Low	95.00
1120115W	43X Phase Objective, Bright Contrast-High	95.00
3220115W	43X Phase Objective, Dark Contrast-Low	95.00
6420115W	43X Phase Objective, B Minus Contrast-Medium	95.00
2120127W	97X Phase Objective, Bright Contrast-Medium	120.00
2220127W	97X Phase Objective, Dark Contrast-Medium	120.00
8420127W	97X Phase Objective, B Minus Contrast-Low	120.00
3120127W	97X Phase Objective, Bright Contrast-Low	120.00
1120127W	97X Phase Objective, Bright Contrast-High	120.00
3220127W	97X Phase Objective, Dark Contrast-Low	120.00
6420127W	97X Phase Objective, B Minus Contrast-Medium	120.00
1142	Huygenian 10X Paired Eyepieces	13.00
142	Huygenian 10X Eyepiece	6.00
1181	Phase High Eyepoint 10X Paired Eyepieces	27.00
181	Phase High Eyepoint 10X Eyepiece	13.00
1182	Phase High Eyepoint 15X Paired Eyepieces	27.00
182	Phase High Eyepoint 15X Eyepiece	13.00
1135	Wide Field 10X Paired Eyepieces	27.00
135	Wide Field 10X Eyepiece	13.00
1000900	Centering Telescope	20.00
735C	Microscope Lamp, 100-watt, with multiple filter holder	72.00
743	Neutral Density Filter, 50% transmission	5.00
85	Single Body Tube with adjustable draw tube	23.00

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